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**HIGHLIGHTS OF NATURAL RESOURCES
MANAGEMENT**

**A Report on National Park Service Natural Resources
Management Activities in 1988.**

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1988

Natural Resource Report NPS-NR-89-01

United States Department of the Interior
National Park Service

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PROTECTING ENDANGERED SPECIES

Red Wolf Recovery Effort Intensifies In Cooperation with the National Park Service

[Reprinted from the *Endangered Species Technical Bulletin* Vol. XIV Nos. 1-2 (1989)]

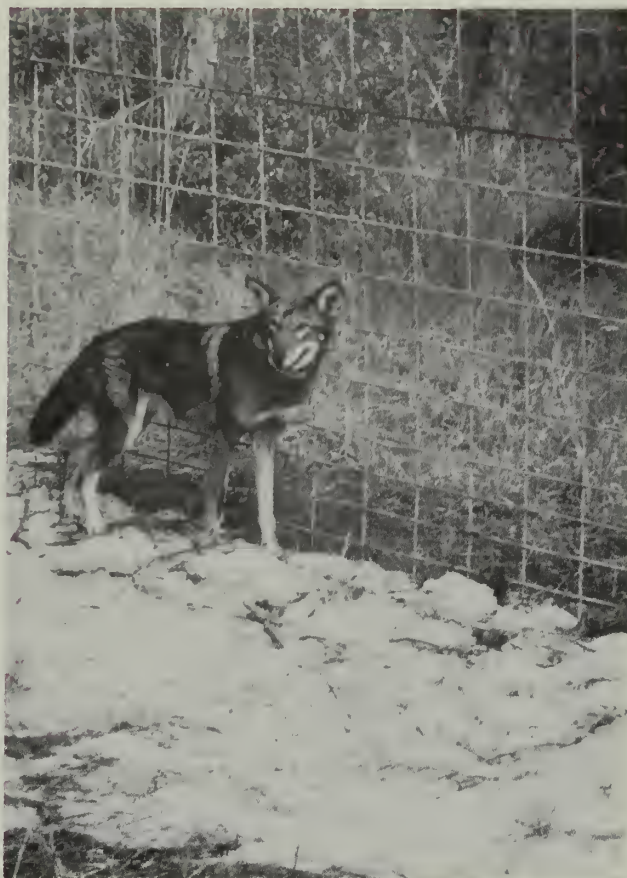
The effort to recover the endangered red wolf (*Canis rufus*) is expanding on a variety of fronts. In 1980, the species was extinct in the wild. As of February 1, 1989, there were a total of 84 red wolves, 45 of which were in the Fish and Wildlife Service/Point Defiance Zoo captive breeding project in Graham, Washington. The remaining wolves were in other captive breeding facilities, acclimation pens, and the wild. The Fish and Wildlife Service is moving ahead to increase both the number of wolves in the wild and the number of facilities and island sites used to propagate wolves.

Eleven red wolves are being held in acclimation pens and four are free on Alligator River National Wildlife Refuge in eastern North Carolina, the first mainland site where the species has been released back into the wild. Of the four pairs of captive-raised wolves released originally in September 1987, two females died from uterine infections, two males were killed by automobiles, one female had to be euthanized after being injured in a fight, and one male choked to death on part of a raccoon—a very unusual occurrence. (The Fish and Wildlife Service's National Wildlife Health Research Center in Madison, Wisconsin, examined the wolf's tissues and discovered no abnormalities.) The remaining male and female were recaptured and placed temporarily back into the acclimation pens to be bred. Biologists have determined that the best way to propagate captive-raised red wolves is to breed them in acclimation pens.

It is thought that the high mortality rate experienced by the captive-raised wolves when they are released into the wild is due at least in part to a lowered immunity to infection. After two or three generations in captivity, the animals may be faced with immune systems that cannot cope with various diseases encountered in the wild. To overcome this potential problem, the Fish and Wildlife Service is trying to move away from releasing only captive-raised animals and focus more on using animals raised in the wild. This strategy entails releasing captive-born pups into the wild as soon as possible. The use of islands as propagation sites also shows much promise.

One propagation island site was established on January 10, when a pair of adult wolves were placed in an acclimation pen on Horn Island, part of the Gulf Islands National Seashore administered by the National Park Service. The 3,500-acre island, part of the

National Wilderness Preservation System, is 8 miles from the coast of Mississippi. After pups are born, the wolves will be free to roam the island for 8 to 9 months. Then the adults will be recaptured and bred again; the pups will be recaptured, moved to the Alligator River Refuge, and released.



Efforts are also being made to increase the captive red wolf population in order to expand the species' gene pool. Some of these animals will be bred with wild wolves, but most will remain in captivity for their lifetime. Eight facilities are cooperating in the captive breeding project: Audubon Park, New Orleans; Alexandria Zoological Park, Alexandria, Louisiana; Texas Zoo, Victoria, Texas; Burnett Park Zoo, Liverpool, New York; Tallahassee Junior Museum, Tallahassee, Florida; Wild Canid Survival and Research Center, Eureka, Missouri; and the Los Angeles Zoo. The Fossil Rim Wildlife Center at Glen Rose, Texas, will be joining the program shortly, and a number of other facilities probably will be participating in the future. All of these cooperating facilities have agreed to breed

red wolves and pay for their upkeep. In addition, the Fish and Wildlife Service is continuing to fund the captive breeding effort in Graham, Washington, operated by the Point Defiance Zoo.

The Red Wolf Recovery Plan was rewritten and a draft of the plan was made available for public comment in the spring of 1989. In addition, new propagation islands are being identified. A potential new mainland release site also may be identified later this year. In the future, Alligator River Refuge will probably serve in part as a "half-way house": wild wolf pups from the propagation islands will be temporarily placed in the refuge and then translocated to other mainland release sites as they become available. Although the red wolf has a long way to go before it can be considered a recovered species, the future is beginning to look promising.

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Dune Thistle Unique to Great Lakes Gets Research Attention

When the great glaciers moved out of Lakes Superior, Michigan, and Huron, a new species of thistle developed in the sand dune habitat created along their shorelines. Today dune thistle, or *Cirsium pitcheri* (Torrey) Torr. and Gray, is a federally threatened species. A fuzzy blue-green plant with cream-colored flowers, a dune thistle is produced only once during its five- to eight-year lifespan. Because it developed with the post-glacial landscape, its ecology is uniquely attuned to the natural cycles of dune building and plant succession of Great Lakes dune systems.

Dune thistle is a pioneer species that colonizes areas of open, blowing sand. As the roots stabilize the sand, other species begin to grow. These other plants are better competitors for the scarce water and nutrients of the dune habitat, and eventually crowd out the dune thistle. This means that once the thistle flowers, its seeds must reach the next pocket of suitable open habitat in order to germinate and grow into the next generation. Development of dunes for industrial, housing, and transportation uses has interrupted this dispersal pattern, causing dune thistle to go extinct in large areas of its former range.

Luckily, though, the states of Wisconsin, Indiana, and Michigan, the U.S. Forest Service, and the National Park Service manage dunes for recreation and conservation where habitat for dune thistle still exists. Some of the most extensive habitat occurs at three national lakeshores: Pictured Rocks on Lake Superior, and Sleeping Bear and Indiana Dunes on Lake Michigan. In 1988, the National Park Service initiated an intensive study of dune thistle populations at these lakeshores. The study is designed to provide details on species ecology, habitat requirements, and regional distribution patterns. This information will be used to develop long-term monitoring and management plans for dune thistle at the lakeshores. By understanding the ecology of a species so dependent on natural cycles unique to dunes of the Great Lakes, we can better plan for management benefitting all users of our dune lands.

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Rare Plants Protected on Blue Ridge Parkway

In 1986 a rare plant survey was completed at Craggy Gardens, a high elevation area on the Blue Ridge Parkway. The information gathered indicated that visitors scrambling across the peaks and taking cut-off trails were trampling the unusual floral communities of the rock outcrops. A study of visitor movements found that over 100 people reached the top of Craggy Pinnacles on a summer weekend day, and that over 500 reached the pinnacle on a fall colors weekend day. While viewing the scenery or finding a place to sit, nearly two-thirds of the visitors moved out onto rock outcrops and into rare plant habitat.

In 1987, initial experimentation with brushing to close informal trails and common routes across the rocks failed. Of 14 brushings, 6 brushings were completely destroyed and 4 were ineffective. Within two months, 12 of 14 were destroyed.

During 1988, new brushings were constructed at the beginning of the summer and marked with interpretive signs. These lasted until fall colors season, when high visitation led to partial disruption of these "natural" barriers. During 1988, the Blue Ridge Parkway developed an interpretive plan for the Craggies. The plan considers the need for trail closures and attempts to use interpretation to mitigate undesirable impacts of visitors on endangered plants. With the implementation of this plan and the construction of a visitor overlook, specially designed to protect the unique ecosystem, informal trails can be effectively closed.

During 1988, seeds were collected from rare plants on the Craggies, and the NPS Cooperative Park Studies Unit (CPSU) at the University of Georgia evaluated rare plant microhabitat preferences. During 1989, the seeds will be regenerated and damaged rare plant communities will be experimentally restored.

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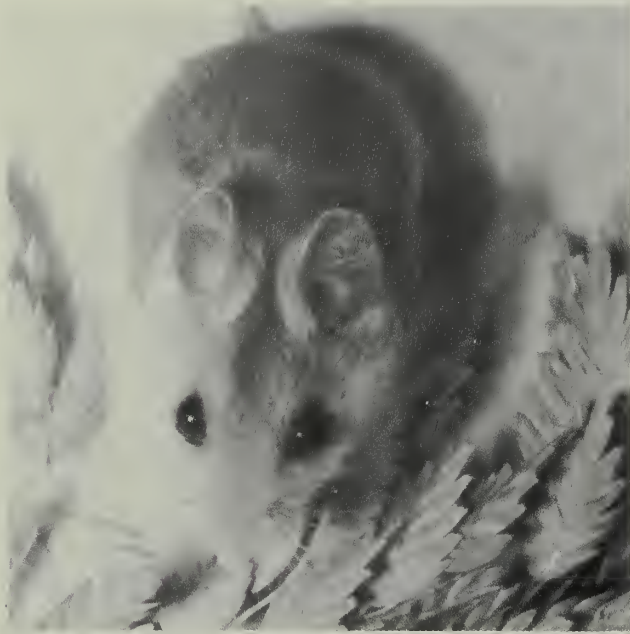
Endangered Beach Mice Repopulate Florida Beaches

A trapping survey for the Perdido Key beach mouse (*Peromyscus polionotus trissyllepsis*) was conducted last summer at Gulf Islands National Seashore (GUIS) on Perdido Key, Florida. The survey indicates that this population, which was reintroduced during 1986-1988, is successfully reproducing and expanding into available dune habitat. In July 1988, 55 individual mice were live-trapped in 2,185 trapnights. Mice were trapped along a 3.9-mile stretch of dunes, and mouse sign was found along the dunes for an additional 2.9 miles.

Historically, this subspecies inhabited dune habitat extending from Perdido Bay, Alabama, to Pensacola Bay, Florida. Ideal habitat for beach mice consists of well-developed dunes vegetated with sea oats (*Uniola paniculata*), beach grass (*Panicum amarum*), and bluestem (*Andropogon marinus*). Beach mice live in burrows constructed in the dunes and are believed to feed primarily on beach grass seeds, herb seeds, and insects. Extensive development, heavy human traffic along Perdido Key, and tropical storm damage to the dunes led to the subspecies' decline, and it was listed in 1985 as endangered.

Perdido Key was surveyed for beach mice in July 1979, and researchers used trap data to extrapolate population numbers. At the time, the estimated number of remaining Perdido Key beach mice was 78 individuals--26 at Gulf State Park (Baldwin County, Alabama) and 52 at Gulf Islands National Seashore (Escambia County, Florida). No mice were found on the central portion of the Key, although about 1.4 miles of dune habitat (Perdido Key State Preserve) is publicly owned.

Perdido Key beach mouse numbers declined considerably following damage to the dune habitat from Hurricane Frederick in September 1979. Because of the Key's narrow configuration, its dune system is particularly vulnerable to hurricanes. In 1982 only 13 beach mice were trapped at Gulf State Park; no beach mice were found on any other area of the Key, and the GUIS population was assumed to be extirpated. Population growth may have occurred at Gulf State Park following the 1981 survey, but the estimated population for this area in April 1986 remained at 31 or fewer individuals.



Recovery efforts for the Perdido Key beach mouse began in November 1986, when the first three pairs were translocated from Gulf State Park to Gulf Islands National Seashore, and 12 additional pairs were relocated between January 1987 and April 1988. Initially, the translocated mice were released into a large protective enclosure and allowed to establish burrows before outlets were made in the structure. Later releases were made into small enclosures where mice were held for one night. Sunflower seeds and water were provided for the enclosed mice. A follow-up survey in November 1987 revealed that the reintroduced population was reproducing. In addition to the one released mouse that was trapped, three unmarked mice were captured. Two of these unmarked mice were females, one of which was pregnant and lactating. Furthermore, mouse sign was found along 0.7 miles of dune habitat on Gulf Islands National Seashore.

Recovery efforts for this endangered beach mouse include maintaining a breeding colony at Auburn University, Alabama. Perdido Key beach mice have not yet reproduced in captivity. The recovery effort for the Perdido Key beach mouse is a cooperative project involving the Florida Game and Fresh Water Fish Commission, National Park Service, Fish and Wildlife Service, Alabama Department of Conservation, and Alabama Cooperative Fish and Wildlife Research Unit.

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Isle Royale Wolves Progress Report

Year one of a two-year investigation into the cause of declining wolf numbers at Isle Royale is now complete. Four wolves were live-trapped, radio-collared, and sampled in May 1988, and most laboratory results are in. All four trapped wolves (two males, two females) appeared healthy when trapped and apparently remain so at this time. The three main hypotheses for decline are (1) lack of food, (2) disease, and (3) lack of genetic variability.

All four animals tested negative for heartworm. Three of the four were positive for canine hepatitis, a common canid disease not thought to be a significant factor in the current situation at Isle Royale. Laboratory results show that two of the four wolves tested positive for canine parvovirus antibodies, and three of the four tested positive for Lyme disease antibodies. These results indicate that the animals have been exposed to these diseases but do not indicate anything definitive about general population health or mortality.

Parvovirus and Lyme disease have never previously been reported at Isle Royale, and concern focuses on these two diseases. Preliminary results of state-of-the-science genetic analysis of the Isle Royale wolves are expected in late March 1989.

The 1989 winter field season revealed 11 wolves, a decline of only 1 since the previous year, but still the lowest number since surveys began in 1959; 1 of those 11 was a pup born in 1988. The rate of wolf decline has slowed, though the lack of successful reproduction remains a major concern. There is not large pack, though there are four male-female pairs. Whether any will breed successfully this year is, of course, unknown.

Moose declined approximately 15% in 1989 to 1,395 (+/- 210), and most autopsied animals showed signs of food stress. The hard winter, unusually high numbers of winter ticks, and/or long-term browse decline caused by high moose densities may be responsible.

A meeting of wolf biologists, NPS scientists, and all scientific collaborators involved in the current investigation was held in March in Minneapolis. The purpose of the meeting was to review the evidence that disease is playing a role in the population dynamics of wolves in the region, and specifically at Isle Royale. NPS scientists and managers will use the ideas generated at this meeting to develop strategies

for wolf management in the coming year, and begin to formulate alternatives for the longer term.

If wolves die out at Isle Royale, ecosystem effects are likely to be profound, since the wolf is a keystone predator that enhances the diversity and abundance of other mammals through heavy predation on moose. Without wolves, we expect an increased moose population and a decline in the quality and quantity of browse available for moose and other herbivorous animals, especially beaver and snowshoe hare. The changes in forest community structure and function would likely influence other predators, birds, invertebrates, and plant species.

Robert Krumenaker
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Isle Royale National Park

Buck Island Reef Hawksbill Sea Turtle

Buck Island Reef National Monument is located 1.5 miles north of the island of St. Croix, U.S. Virgin Islands. Buck Island is well documented as a nesting area for three endangered species of sea turtle: the leatherback, the green turtle, and the hawksbill. In 1987, intensified diurnal sea turtle monitoring efforts indicated that the hawksbill turtle was nesting on Buck Island National Monument in significant numbers.

In 1988, a three-month nocturnal research program was added to daily diurnal sea turtle monitoring patrols. The nocturnal research program objectives were to collect basic biological information on hawksbill sea turtle nesting on Buck Island, to test the feasibility of tagging turtles for a long-term population study, and to identify various management concerns (i.e., erosion, poaching, recreation, and predation and their effect on hawksbill nesting success).

During the nocturnal monitoring period (June 5 through August 15), 23 hawksbill activities were observed. An additional 33 activities occurred unobserved during the 1988 nesting season, which began in May, peaked July through September, and ended in late December. Twelve hawksbills were inconel-tagged (PPW 800 series, NMFS tags) and six of these were also paint-tagged. In 1988, 88 nests were confirmed, the average clutch size was 140.3 eggs, mean hatching success of nests surviving to term was 80.9%, and approximately 6,800 hawksbill hatchlings were released from Buck Island.

In 1987, 46 nests were confirmed and mean hatching success for nests surviving to term was 83.5%. The number of confirmed nests increased more than four-fold between 1985 and 1988 as a result of intensified diurnal and nocturnal monitoring efforts.

Several management concerns were identified: (1) beach debris limited access to stable nesting grounds, (2) predation reduced nest success; seven nests were lost to the great land crab in 1988, although historically the mongoose has been the primary predator, (3) poaching, a serious concern in the past, was virtually eliminated in 1987-1988 by program publicity and the presence of research personnel, (4) the effects of recreation were minimized by prohibiting all types of activities using poles, stakes, or digging on nesting beaches during the nesting season, and (5) reduction in nest success due to erosion. In 1988 approximately 8% of confirmed nests were lost to erosion; normal



rainfall and storm flooding eroded the shoreline vegetation, exposing roots and preventing access to stable nesting areas.

The biological data collected during the 1988 season have established a baseline of information on the hawksbill nesting population at Buck Island. The return of tagged animals will now provide information on site tenacity, remigration, fecundity, and tag loss for this endangered and poorly documented species. In the light of the continued loss of nesting habitat to development in the wider Caribbean, protected areas such as Buck Island play a significant role in the conservation of the hawksbill sea turtle. Buck Island National Monument will continue this nocturnal research program to monitor nesting hawksbill sea turtles for 10 weeks (mid-June to mid-August) during the 1989 nesting season.

Zandy-Marie Hillis
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Buck Island Reef National Monument

Wolf Research in Denali

A solo camper in Denali National Park and Preserve, Alaska, unknowingly pitches his tent a half-mile from a wolf rendezvous site. He spends a nervous night watching four wolves circle his tent, howling and barking. The wolves are upset as well, and move their pups to a new site. In winter a gray wolf trots across the frozen Nenana River, not knowing that in mid-river his status changes from tourist attraction to potential parka ruff. A hundred miles west, a small airplane circles and dips along the edge of the Alaska Range, looking for wolves to shoot from the air.

In spite of the vast size of Denali National Park and Preserve, the remoteness of its backcountry, and the undeveloped nature of the surrounding area, human activities can potentially affect all of the animals that live within its borders. This is especially true of wolves, because of their wide-traveling habits, their potential value as furbearers, and their controversial role in affecting prey populations.

In order to determine how Denali's wolf population was being affected by human activities, a radio telemetry study was begun in 1986. To date, 68 wolves from 23 social groups have been radio-collared, mostly by helicopter darting in winter. Over 3,000 locations have been obtained from these wolves, providing a picture of wolf demography and food habits over most of the 6 million acres of Denali National Park and Preserve. None of Denali's wolf packs remain entirely within the park's wilderness boundary; thus, all of Denali's wolves are potentially subject to legal hunting and trapping. In fact, collared wolves have been killed both by legal trapping outside the park and illegal aerial hunting inside the park.



The current level of human interference is low, and so the Denali wolf population and the prey populations it depends on remain largely unaffected by human activities. This undisturbed predatory-prey system provides the opportunity for ecological research in addition to the original management-oriented goal of the current wolf study. Denali contains over 2,000 caribou and similar numbers of moose and sheep. The interaction of these populations with their predators (primarily wolves and bears) is being studied for comparison with the more manipulated ecosystems found elsewhere in the north.

The remains of over 500 prey animals have been examined to determine the age, sex, and condition of prey selected by wolves. We have found marked seasonal changes in prey use, evidence that wolves key in on particular classes of prey at particular times. We have also seen evidence that the reproductive success of wolves depends on the availability of their prey.

The wolf project in Denali is scheduled to continue for two more years. The results will help park staff assess the effects of increased human activity in and around the park, and will also help scientists understand the workings of this system of large predators and their prey.

Tom Meier
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Denali National Park and Preserve



Monitoring Peregrine Falcon Population at Glen Canyon

Peregrine falcons have been placed in urban areas such as Salt Lake City and Denver in an effort to encourage a population recovery for this endangered species. But at Glen Canyon National Recreation Area, that recovery appears to be taking place in a decidedly natural way--by the birds themselves.

Monitoring of the peregrine falcon population in Glen Canyon was begun in 1983 and has continued annually. The 1988 survey counted 21 occupied territories lakewide compared to 3 such territories identified in the 1983 survey. The number of known territories has increased as new areas were examined and the efficiency of monitoring increased through experience. Falcons at Glen Canyon nest on ledges or in potholes high on cliffs along the shore of Lake Powell or in the larger tributary canyons. Eggs are laid in "scrapes" on the bare rock or in sand.

Besides an increase in the number of occupied territories, surveyors have also recorded increases in the number of birds, the number of nests, and the number of young. Of the 34 known territories within Glen Canyon National Recreation Area, 20 territories were occupied in 1988 by pairs of peregrines and 1 by a pair of prairie falcons. Occupancy could not be determined in the other 13 territories. Ten peregrine eyries were confirmed in which 24 young were counted. Two eyries are suspected to have failed, while the outcome of the remaining nine occupied territories was inconclusive due to insufficient data.

The Peregrine Foundation, which funds much of the recovery effort being made today, estimates that an average of 1.6 young must be produced per nest to sustain the population. Glen Canyon's average of 2.4 young falcons per nest where breeding occurred is considered to be more than adequate to sustain a population. It is widely believed that the peregrine falcon population has been expanding rapidly on the Colorado Plateau through the decade, possibly as a result of reduced pesticide use elsewhere. The increased number of birds known to breed at Glen Canyon is probably the result of this population expansion and the additional knowledge gained through organized monitoring.

Once the young are fledged, peregrine falcons no longer use their nests. NPS personnel scaled cliffs in 1988 to reach two eyries once the young had been fledged to obtain shell fragments for testing and prey remains.

The shell fragments were measured for thickness, an indication of exposure to pesticides that cause egg shells to become thin and break before successful hatching can occur. The fragments from Glen Canyon proved to be about 12% thinner (.315 mm) than the "standard" (.359 mm). Thinning of 15-20% is believed sufficient to interfere with reproduction. These results suggest that falcons successfully breeding at Glen Canyon still have a significant pesticide load in their tissues. If this loading is representative of the Colorado Plateau population, a small increase in contact with pesticide-laden prey could result in a renewed decline.

Prey remains could be positively identified from only one of the two eyries visited (identification of prey remains was provided by Dr. Clayton White of Brigham Young University). The collection contained red-necked phalarope, two gull species, dove, evening grosbeak, two jay species, a cowbird, coot, and ten clark's nutcrackers. Several of the species are present only during migration, while others are upland birds. The nutcrackers were probably taken from the mid-elevations of Navajo Mountain or higher, 11 kilometers from the eyrie. These results are not only an indication of the falcons' varied diet, but that there is probably seasonal variation in prey availability. Results also suggest that the birds from at least this particular eyrie forage extensively on uplands away from their lakeside nest habitat.

Considerable effort was expended in the 1988 survey, resulting in significant gains in the park's information base about falcons. An important benefit was the development of monitoring skills within the staff, since all field divisions were involved in at least a portion of the survey; 40% of the project time was volunteered. Due to the park's large size and the fact that peregrines are now known to occupy virtually the entire area, Glen Canyon will continue to monitor the birds on a sample basis instead of monitoring all known territories each year. For the years 1989-1991, the park plans to monitor a geographic one-third of the park each year (including surveying remaining new areas). The park will continue to collect eggshell and prey data and has proposed studies to investigate preybase populations and the developing shoreline habitat along Lake Powell.

Charles W. Wood
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Manatee Telemetry Proves Salt Marsh Key Habitat at Cumberland Island

In 1986, a Manatee Watch effort by NPS and University of Georgia CPSU staff found endangered west Indian manatees (*Trichechus manatus*) to be frequent summer visitors to the tidal creeks and docks of Cumberland Island National Seashore. Concern over the possible impacts of deep dredging for Trident submarines entering the Kings Bay Naval Submarine Base, just to the west of Cumberland Island, has prompted further study of manatee movements and habitat use in the Cumberland Sound.

A telemetry project, under the technical supervision of the Fish and Wildlife Service Sirenia Project, in cooperation with the National Park Service and the Department of Defense, captured four manatees in the Cumberland Sound area during 1987-1988 and tagged them with specially designed radio transmitters. The project has also located four manatees originally tagged by the Fish and Wildlife Service in Brevard County, Florida, (near Canaveral) and followed them by boat, truck, or plane as they moved into south Georgia waters. The tag consists of a floating transmitter tethered by a flexible rod to a padded belt around the base of the animal's tail. While the flexible tether is designed to avoid entanglement, a weak link in the assembly allows the manatee to break free if the tag gets caught. Each transmitter has a unique frequency and is also marked by distinctive colored bands so animals can be visually identified. Manatee capture requires a large, well-supervised crew, who surround the animal and calm it while a padded belt is fitted to the tail. Chemical immobilization is avoided since it increases the risk of an animal being injured or drowning. Tagging in the Cumberland Sound area is usually done in shallow water at paper mill effluents (discharge sites).

The project has found that a few manatees use the warm water effluents at paper plants and sewage outfalls throughout the year. Manatees moving into the Cumberland Sound area in late winter and early spring, when the water is still cold, may stay around the outfalls temporarily before moving further north. While at the outfalls, manatees swim out into the tidal creeks when the tide comes in and high water allows them access to cord grass (*Spartina alterniflora*) growing on the creek banks. *Spartina*, which is often the only emergent plant species in the marshes used by manatees, appears to be a key food item. Manatees have also been observed feeding on algae. Manatees from the project have been recorded a number of times in Beach Creek and Old House

Creek on Cumberland Island. One of the male manatees, originally tagged in Brevard County, spent the summer of 1987 and 1988 foraging in Kings Bay (within the boundary of the submarine base), and along the shoreline of the Cumberland Sound. A female manatee, who used Cumberland Sound for most of the summer of 1987, returned in early April 1988, but then traveled south again in June and spent the remainder of the warm season at Indian River in Florida. Other manatees tracked in the Cumberland Sound region have moved into freshwater Georgia rivers, such as the Satilla and the Altamaha, as the weather warmed.

The project has identified the tidal creeks in *Spartina alterniflora* marsh as key seasonal habitat. The data on manatee movements have led to a new emphasis on protecting manatee habitat in the northern portion of manatee range and have documented manatees as summer residents in the Cumberland Sound - South Georgia region.

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UNDERSTANDING OUR RESOURCES

A Tick Attack in the North Woods

A standard research procedure of preserving specimens for later use--in this case, parasites from a comprehensive bird study--proved fortuitous. When examined in light of new informational concerns, the specimens provided insights on Lyme tick disease.

The Saint Croix River Valley serves as a corridor for birds migrating from the western Great Lakes and boreal regions to the neotropics. Nearly 62% of the 291 bird species recorded for the valley, and the riverway, are regarded as long-distance neotropical migrants. During migration the birds follow the valley with its diverse biological communities. A study of fragmented habitat use by migrating land birds has been conducted at two localities 125 km apart on Saint Croix National Riverway since 1984. During this study, over 48,000 individual migrants representing 125 species were captured. These birds were examined and series of measurements and observations were recorded for each. Incidental to other data collected, ectoparasites were removed from each bird when found and preserved for later study.

Elsewhere, Lyme borreliosis, the collective term for Lyme disease and related disorders, was newly recognized by the North American medical community and it was found to be transmitted by several species of ixodid ticks which carry the spirochete bacterium *Borrelia burgdorferi*, the disease pathogen. Lyme borreliosis is often difficult to diagnose because it mimics other common diseases, and inappropriate or delayed treatment can result in severe chronic or acute afflictions involving the musculoskeletal, cardiac, or nervous systems. The disease has three endemic foci in North America, southern New England to the middle Atlantic states, southern Oregon and northern California, and Minnesota and Wisconsin, from which it appears to be spreading. The Saint Croix River Valley is centrally located in the latter area where the disease is increasingly reported with worrisome frequency.

The tick *Ixodes dammini*, a common vector of Lyme borreliosis, was a common ectoparasite removed from the migrating birds in 1986. Only immature ticks were found on the migrating birds. Subsequently, during 1987 all ixodid ticks were taken alive and examined for the presence of the borreliosis spirochete in the microbiology laboratories at the University of Minnesota Medical School. *Borrelia burgdorferi* was found in 22% of the 256 ticks removed from the migrating birds. In addition, spirochete positive larvae were removed from recaptured migrants from which ticks had been removed previously. This indicates that

birds were infected with the spirochetes and they transmitted them to the ticks. The tick-infested birds represent only 0.6% of the captured migrating birds.

It is increasingly clear Lyme borreliosis is a serious malady affecting particularly those persons whose work or recreation takes them into habitats containing the disease vectors. It is also clear that migrating land birds are probably an important, but as yet unknown, factor in the ecology and epidemiology of this insidious spirochetic infirmity.

The original study of the use of fragmented habitats by migrating birds was supported by The Belwin Foundation, The Carolyn Foundation, the Minnesota Department of Natural Resources, and the Midwest Region of the National Park Service. The Science Museum of Minnesota provided field laboratory facilities.

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Paleoecological Studies of Vegetation and Fire at Howe's Prairie

Howe's Prairie, an isolated prairie within Indiana Dunes National Lakeshore, contains an abundance of rare prairie species. Many of these species, such as marsh blazing star (*Liatris spicata*), rattlesnake master (*Eryngium yuccifolium*), and big bluestem (*Andropogon gerardii*), were more widespread within the dunes during the early parts of this century. Visual and photographic evidence from the last few decades document the persistent invasion of woody species into the prairie, most notably black oak (*Quercus velutina*).

Fire suppression has been proposed as the most likely cause of the degradation of this prairie. This hypothesis was investigated through an analysis of the past history of the prairie using several paleoecological techniques.

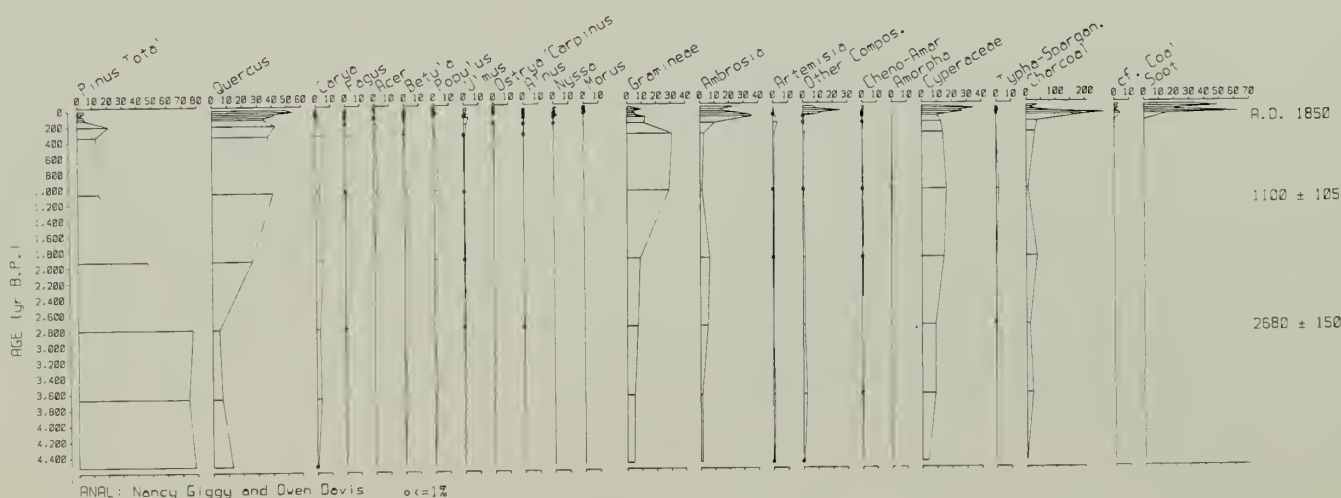
Long-term data on the prairie history was provided by pollen analysis of a section of peat from the prairie. This analysis (see illustration) demonstrates the history of the prairie over the last several thousand years and reveals several important trends. During the last three thousand years the prairie has followed the classic successional sequence for the dunes from pine forest to prairie and oak woodland as was first proposed by Henry Cowles in 1891. However, in the settlement period (post 1850 A.D.), several notable changes have occurred. The pine forest (*Pinus sp.*), already in decline due to long-term succession, was almost totally eliminated by lumbering. Ragweed (*Ambrosia*

sp.) pollen became abundant due to disturbance caused by the clearing of nearby farm fields. The combined effect of the post 1850 A.D. changes is so large that these post-settlement changes are an order of magnitude greater than presettlement rates of change. This suggests that observed trends of the last century may not be applicable to natural vegetational processes.

The most surprising signal from this sediment core is the charcoal chronology (right side of illustration). Rather than simply decreasing due to post-settlement fire exclusion, as would be predicted from traditional hypotheses, there is a more complex record. The abundance of charcoal within the core soars above presettlement levels with the early phases of settlement along with particles identified as coal and soot. These records are caused by the completion of several railroads within 5 km of the site by 1855. The steam locomotives greatly increased charcoal production by producing sparks, providing a more frequent ignition source. Slash burning from the lumbering operations probably also increased fire frequency.

During the last 50 years, charcoal production has dropped to a magnitude approaching presettlement levels. However, the vegetation is still quickly changing, rather than returning to its presettlement condition. Additional hypotheses on the relations between fire regime, climate, and vegetation dynamics are currently being explored through prescribed research burns, presettlement survey data, and additional paleoecological data.

Ken Cole
Plant Ecologist
Indiana Dunes National Lakeshore



Baseline Water Studies, Glacier National Park

One of the key indicators of man-caused pollution is water quality. Although the lakes and streams of Glacier National Park have been thought to be unaffected by man-caused pollution, water quality data did not exist prior to 1984 to support this belief. Glacier is surrounded by land use activities that could threaten its pristine waters, and air, vegetation, and wildlife resources. Concerns range from sediment pollution in the North Fork of the Flathead River from logging and road construction and potential acid precipitation from coal-fired power plants in northwestern United States and southwestern Canada to airborne pollutants on a global scale that may affect the environment.

In order to establish a water quality baseline for Glacier National Park, a long-term monitoring program began in 1984. Studies include monitoring of five large frontcountry lakes which have shoreline developments and moderately heavy visitor use and eight backcountry lakes which lie in remote headwater areas of the park.

Water samples are analyzed for a variety of chemical, physical, and biological parameters. Acidity and conductivity are recorded onsite. Chemical and biological analyses are done by the University of Montana's Flathead Lake Biological Station.

The results and data are published in an annual report, with year-to-year data compared for detecting any change. A sound baseline is being established, and no evidence of anthropogenic pollution exists to date.

H. Gilbert Lusk
Superintendent
Glacier National Park

Glacial Outburst Floods, Mount Rainier

An increased frequency of glacial outburst floods have occurred at Mount Rainier in recent years, particularly along Tahoma Creek. Floods and associated debris flows have caused extensive damage to developed areas along and including the West Side Road. Outburst flood frequency has increased from a rate of about three per decade during the 1970s and early 80s to about three or four annually during the last few years. This frequency likely reflects significant changes in the internal drainage system and water-storage characteristics of the south Tahoma Glacier; other glaciers on the mountain may be experiencing similar changes.

This study is providing information needed to understand the dynamics of glacial outburst floods and to develop predictive capabilities. Study results are being used for planning future repairs and developments along the Tahoma Creek drainage and for developing additional interpretation media on the glaciers of Mount Rainier.

Automatic cameras, pressure transducers, a sonic ranger, and other instruments were installed during 1988 for monitoring outburst flood debris flows at Tahoma Creek. A general geologic reconnaissance was conducted following each event. All of the equipment, however, was destroyed during a flood and debris flow that occurred on October 16. Future work is planned to collect field data on the floods by means of automatic cameras and other sensors. Glaciological field studies are also planned to characterize englacial and subglacial hydrology. Field studies will be combined with theoretical modeling of englacial and subglacial water storage and release.

USGS investigators include Joseph Walder, Carolyn Driedger, C. Swift, J. Costa, L. Reed, and others from the USGS Vancouver Volcano Observatory and the Tacoma Office. Project coordinator is Barbara Samora.

Barbara Samora
Resource Management Specialist
Mount Rainier National Park

Water Quality Monitoring at Curecanti National Recreation Area

Curecanti National Recreation Area, located at the head of the Colorado River drainage, is comprised of three man-made reservoirs containing water of relatively good quality. As the concern over the Colorado River system increases, the Curecanti water storage reservoirs will come under greater pressures, requiring the accurate monitoring of reservoir and tributary water quality.

Variations of a water quality monitoring program implemented in 1982 have continued the past seven years at Curecanti National Recreation Area. The initial program consisted of measuring a number of physical and chemical parameters as well as a host of heavy metals. The program has been forced to be cut back in some areas, but the measurement of a number of the original physical and chemical parameters has continued.

Samples are collected from each of the major tributaries of Blue Mesa Reservoir to monitor effects of activities taking place adjacent to the park. These activities include energy, mining, and residential development. Samples are also collected and analyzed from sites on Blue Mesa Reservoir to monitor overall water quality and to determine the stage and rate of reservoir aging.

In 1988 more emphasis was placed in determining the stage of the reservoir aging process in an attempt to better understand the current condition and the future management needs of the Blue Mesa fishery. Blue Mesa Reservoir, the largest lake in the state of Colorado, has become well known for its fine fisheries resource. As the importance of this resource increases, the importance of understanding the aging process and of maintaining a high level of water quality will also increase.

Ken Stahlnecker
Resource Management Specialist
Curecanti National Recreation Area

Developing an Inventory and Monitoring Program at Shenandoah National Park

A special park initiative was begun in 1987 to develop a comprehensive inventory and monitoring program for Shenandoah National Park. The first phase of this effort was to implement a parkwide system of ecological monitoring plots that would serve as the core of the monitoring program. This initial phase was started in 1988 and is expected to take four to five years to complete. These long-term ecological monitoring plots are being established systematically throughout Shenandoah. The system consists of aquatic and terrestrial components. Seventeen aquatic plots (100m stream stretches) are sampled quarterly for water quality parameters, and semi-annually for habitat and discharge measurements. Benthic macroinvertebrates are sampled in the spring and fall of the year. Stream plot locations were selected to represent major bedrock geological types, elevational zones, and juxtaposition within the park.

Terrestrial plot sites are located in a stratified random design using the park's geographic information system by a forest cover type (7), elevational zone (3), aspect (2), and administrative district (3), for a theoretical total of 126 cells. Some cells are not represented in the park because certain combinations of selection criteria are mutually exclusive (e.g., cove hardwoods + high elevational zone + dry aspect). Each cell (site) consists of three 24m x 24m plots, with a series of nested subplots.

In 1988, 111 plots were established at 37 sites in the park; 15 sites were located in the North District, 12 in the Central and 10 in the South. Cells filled include chestnut oak, red oak, and cove hardwood types. Information gathered from these plots includes slope, stand age, overstory tree composition, crown condition, canopy position, understory composition, and herbaceous ground cover. The data will be entered into a computer database management system when the software contract is completed. The program is currently being upgraded to run on dBase IV, providing improved data file handling capabilities. Planned time frame for repeated data collection from terrestrial plots is once every five years, unless a recognized perturbation in the area signifies a need for greater frequency of collection.

Scheduled work for the 1989 field season is similar in magnitude to 1988. The quality of the data gathered will be assured by remeasuring a representative sample of plots established in 1988, and statistically comparing the datasets for no difference.

David Haskell
Resource Management Specialist
Shenandoah National Park

Olympic's Twin Creek Watershed Study - An Overview

Within the national acid precipitation assessment program, Olympic National Park is conducting long-term ecological research into the effects of acid precipitation on a forest ecosystem: the West Twin Creek watershed on the Hoh River system. It appears critically important to the long-term value of this and other watershed studies that monitoring datasets be maintained with no discontinuity. Global and regional crises other than acid rain threaten more than a few trees in this remote, wilderness watershed. To understand the potential effects on Northwest coniferous forests of global warming due to the greenhouse effect, baseline process and community structure information is essential.

The study, which began in 1984, is designed to determine the chemistry of atmospheric inputs to a relatively pristine ecosystem, and to obtain baseline information on the structure and function of the forest. The first two years were devoted primarily to setting up the research site and conducting initial surveys on the forest vegetation and soils of the watershed. The results were presented at the Conference on Science in the National Parks, July 1986, at Fort Collins, Colorado.

In order to detect changes in ecosystem function, several years of monitoring are anticipated. For a clean, protected environment like the Hoh River drainage within Olympic, it can be hypothesized that no change in the functioning of the forest would occur. However, many of the processes being monitored will have naturally high variability, which must be documented as well. The levels of any process must fall outside the normal distribution for that process before any one or combination of factors may account for the change in ecosystem function.

The monitoring of specific forest processes that may be sensitive to acid precipitation began in 1986. Lysimeters to collect soil solution were installed, as was equipment to collect additional precipitation, stream flow, and throughfall samples. Litterfall collectors were installed. The rate of needle decomposition was studied. Tree mortality surveys are conducted on permanent plots within the study area. A permanent weir and stilling well have been installed on West Twin Creek. Hydrological stages and streamwater chemistry are routinely monitored. Some results of our investigations follow.

The annual rate of tree mortality for West Twin Creek watershed was 0.96%. This level is well within the expected range of mortality of old-growth forests of the Pacific Northwest (J. Franklin, pers. comm.) Tree ages were determined for a subsample within each permanent plot. Trees at West Twin Creek are a maximum of 650 years of age. Overall, the trees appear healthy and show no signs of crown dieback or foliar damage due to pollutants or other stresses. Soil samples were collected and analyzed. The organic layer was the most acidic (pH = 3.95). Deeper in the soil profile, the soils become less acidic, probably due to the greater bedrock influence and less contribution from the organic acid producing litter layer.

Ion deposition in precipitation is dominated by sodium and chlorine inputs. This is to be expected due to the proximity to the Pacific Ocean, which serves as a source of these ions. Ion export is dominated by carbonate, calcium, and sulfate. These ions are exported in far greater quantities than they are deposited, indicating that the sedimentary soils of the watershed serve as a source.

The hydrologic system at West Twin Creek is adequately buffered at present against changes in pH. The streamwater discharge remains consistently near neutral. Carbonate is an excellent buffer and its concentrations keep the stream slightly basic at >7.2 pH.

NAPAP support for the West Twin Creek watershed study at Olympic is programmed through FY 90. An assessment of NAPAP results is planned.

To detect and assess change at threshold levels, long-term monitoring programs are highly recommended. The National Park Service must decide soon whether it can afford not to continue such studies after NAPAP.

John Aho
Chief, Natural Science Studies
Olympic National Park

Paleontological Studies in Glen Canyon

Research has been underway since September 1988 on the 190-million-year-old dinosaur tracks discovered by a park visitor. NPS staff verified the find and arranged for onsite evaluation by Dr. Michael Morales, Paleontologist, and Dr. Patty Luttrell, Sedimentologist, both from the Museum of Northern Arizona in Flagstaff.

Trackways were found in two different sites. Dr. Morales indicated that these finds could prove to have great scientific significance for several reasons. The first is that it is extremely rare to find fossils of any type in Navajo Sandstone, the aeolian dune deposit in which these tracks were found. It also is rare to find so many tracks. And, the particular shape and size of the prints point to the possibility of a new species and genus of dinosaur, although it is early yet to be certain.

The trackways have been geologically examined and thoroughly documented, including photographs, sketches, and latex peels. More than 200 tracks were made by at least two species of dinosaur: a four-toed, herbivorous "prosauropod" that walked on all fours, and a bipedal, three-toed "theropod," a carnivore with small forelimbs. These animals lived during the early Jurassic period about 190 million years ago during the early phases of the age of dinosaurs.

The depositional environment indicates the tracks were made in an interdunal area with a moist surface according to Dr. Luttrell. Interdunal areas may have been pathways for animal travel, accounting for the abundance of tracks.

The scientists are preparing a final report on their work and will make recommendations to the park on how best to preserve the tracks. Their conclusions will be published in the peer review literature.

Another paleontological find by a park visitor, this time from a completely different period of the earth's history, led to the discovery of a skeletal fragment from a mammoth. Found on the shore of Lake Powell where wave action had exposed the bone, the material proved to be one-half of a mammoth mandible. The discovery was evaluated and documented onsite, and the bone was salvaged by a team of paleontologists from Northern Arizona University, working under an Antiquities Act permit issued by the National Park Service. The bone is estimated to be 12,000 to 14,000 years in age and is the second mammoth skeletal deposit known within the recreation area.

These events, in combination with similar discoveries made in previous years, highlight the importance of paleontological resources in Glen Canyon where conditions evidently have been favorable for preservation of scientifically valuable deposits. The park plans to continue to place emphasis on the identification, evaluation, preservation, and interpretation of these resources.

Charles W. Wood
Biologist
Glen Canyon National Recreation Area



"Prosauropod" tracks in Navajo Sandstone at Glen Canyon



Paleontologists wrapping mammoth mandible prior to removal

Valley Oak Inventory and Monitoring at Santa Monica Mountains

Valley oaks (*Quercus lobata*) in the Santa Monica Mountains National Recreation Area have suffered for many years from problems brought on by ranching and urban encroachment. The valley oak community of the national recreation area is at the southern boundary of its range and is characterized by alien species and low reproduction of oaks.

As a first step toward restoring valley oak populations and communities, a three-year study (January 1986 through December 1988) was undertaken in the Cheeseboro Canyon, Paramount Ranch, Rancho Sierra Vista, and Malibu Creek State Park areas of the national recreation area. The study was designed to (1) inventory the population dynamics of valley oak, (2) inventory the habitat and community characteristics of valley oak, and (3) design a long-term monitoring program for assessing the health of valley oak populations and communities.

Herbaceous species directly associated with valley oaks were recorded using a series of transects radiating out from individual trunks. Woody species directly associated with these trees were recorded using a 2-meter-wide belt transect. Species in the areas between tree canopies were recorded using a series of randomly placed plots. Eighty trees were tagged for monitoring long-term health of mature individuals. Annual measurements will include dbh, number of acorns, and number of seedlings, which in turn will serve as the basis for a health assessment of each of the eighty oaks. In addition, one tree at Paramount Ranch and one tree in Cheeseboro Canyon have been set aside to track seedling development by marking and measuring seedlings in designated plots.

Karen Danielsen
Biologist
Channel Islands National Park

William L. Halvorson
Research Scientist
Channel Islands National Park

RESTORING, PROTECTING, AND MANAGING OUR RESOURCES

Restoring Bighorn Sheep to Sierra Nevada

Resource managers in the National Park Service often operate in a frustrating arena where success is measured by the degree to which park environments fail to deteriorate. Sometimes, however, they are given the opportunity to restore to nature what she previously had lost. Thanks to the efforts and cooperation of four agencies, three private foundations, and the University of California, California bighorn sheep (*Ovis canadensis californiana*) roam the crest of the Sierra Nevada in the Inyo National Forest and Yosemite National Park for the first time in nearly a century.

State game departments and federal land management agencies throughout the West have been attempting to reintroduce dwindling bighorn to some of their former ranges. Some of these transplants have prospered—at least for a time—and many have failed. What has been largely lacking is information about the factors that lead to success or failure. The California Department of Fish and Game, the Forest Service, and the National Park Service have strived for over a decade to increase the number of California bighorn from the perilous brink of extinction. When this effort led to plans for an introduction on the slopes east of Yosemite National Park in 1986, a critical roadblock was the presence of a domestic sheep grazing allotment dangerously close to the expected bighorn range. The Yosemite Association solicited a grant from The Goldman Foundation that was used to pay the allotment holder to abandon his grazing rights.

There was still concern over the major highway, development in the Mono Basin, and grazing in adjacent canyons. All represented changed conditions from those present when bighorn had graced the peaks in the 19th Century. The National Park Service decided that stakes were too high simply to release the sheep and hope for the best. Western Region Natural Resources and Research funds, augmented by aid from the Yosemite Association and the Sacramento Safari Club, and logistical support from the Forest Service and the California Department of Fish and Game, were brought together in an intense research and monitoring effort.

When the first 27 bighorn were released in Lee Vining Canyon in March 1986, all but 2 wore radio transmitter collars. Les Chow, University of California graduate student, hit the ground with them, destined to track the sheep over the next several years. The following year, Peggy Moore, another University of California graduate student, was added to the project to determine the habitat factors critical to bighorn survival in their new home. Both Les and Peggy plan to use the data they

collect for Masters' Theses. Overall project direction comes from Jan van Wagtendonk and David Graber, Research Scientists at Yosemite and Sequoia/Kings Canyon, respectively. Thanks to the field crew's intensive tracking efforts, information critical to managing the herd was quickly disseminated to the inter-agency team.

Seven sheep died soon after release in fierce late-winter storms. A small band migrated to the next canyon south, effectively eliminated from the reproductive potential of the herd. Pumas (*Felis concolor*) took a substantial number of ewes and subadults. Without the intensive monitoring, these losses and their causes would have gone largely undetected, jeopardizing the herd's chances of survival as the number of reproducing ewes dropped to five. Instead, the interagency advisory group, based on the monitoring data, encouraged the Department of Fish and Game to remove some of the pumas in Lee Vining Canyon to reduce the loss of remaining bighorn, and to add an additional 11 radio-collared sheep, 7 of them adult ewes, to boost reproduction in the new herd. Thanks to these two efforts, by fall of 1988 there were 31 bighorn in Lee Vining Canyon and mortality had declined.

The sheep continue to modify their winter and summer home ranges as they discover new resources. In time their range expansion will probably place some of them in Yosemite during the summer. Unfortunately, they may also wander into domestic sheep allotments on the Inyo where disease could decimate the herd as it has others in the past. But at the moment their prospects are good as the Park Service continues to monitor the bighorn.

David Graber
Research Scientist
Sequoia and Kings Canyon National Parks

Predicting Contaminant Flows and Concentrations on New River

A tank truck has just wrecked, spilling 1,000 gallons of malathion into the river in your park? How long will it take for the spill to reach your swim beach? How concentrated will the chemical be when it reaches the beach? Can you dilute the chemical by releasing more water from a dam upstream?

These are some of the questions that worried the managers of New River Gorge National River, where a main line railroad parallels the New River and two major highways cross the park.

To answer these questions, the National Park Service entered into a cooperative agreement with the U. S. Geological Survey to study how contaminants would act if spilled into the river at different water levels. The first part of the project produced a set of graphs showing how long it takes a flood wave to reach any point along the river after it is released from the Bluestone Dam, located directly upstream from the national river boundary. This information is especially useful for commercial rafters and private boaters who want to know what the streamflow will be for tomorrow's trips.

Secondly, the U. S. Geological Survey released known quantities of a harmless dye into the river. They measured how fast it traveled downstream and how diluted it became at different locations along the river. This was repeated for four different flow levels--from spring runoff to summer droughts. With this information, managers can determine how long it will take a spilled chemical to reach any point along the river, and how concentrated it will be for any given riverflow.

Finally, we wanted to know how a change in flow would change the travel time and dilution of a spilled chemical. With the cooperation of the U. S. Army Corps of Engineers, which operates the Bluestone Dam, the U. S. Geological Survey and the National Park Service repeated the dye studies under conditions when the flow changed, both increasing and decreasing flow rates. Interestingly, we found that increasing the flow rate does not dilute the chemical. It shortens the dye cloud and decreases the time it takes the contaminant to pass any point along the river, but the flood wave resulting from the increase in flow causes the trailing edge of the dye cloud to catch up with the leading edge and the concentration remains almost constant.

This information is now being entered into a computer model, which will enable managers to predict how a soluble contaminant that may be spilled into the river will travel and disperse as it moves downstream.

Meg Weesner
Resource Management Specialist
New River Gorge National River

A New Approach to Exotic Plant Management

A variety of methods that had at least some effectiveness in controlling kudzu (*Pueraria lobata*) either by extirpation or taking it out of ecological dominance were employed on a number of sites in National Capital Region. The replicated treatments (usually involving whole colonies) included physical, chemical, biological, and mechanical methods. Most of the sites received a combination of treatment. To control the kudzu population, the ecology of the species was targeted in the traditional manner of integrated pest management.

To establish why some sites subsequently became dominated by exotics while other sites became dominated by native vegetation, a replicated experiment was performed and tested with Yates' corrected chi-square. The factors which promote or discourage exotic species had previously been summarized for an NPS symposium on exotic species in 1986 (In Press). The sites were classified as forest influenced or nonforest influenced, and as native or exotics dominated.

In the replicated experiment, 48, 22, and 57 sites were tested, and in each a significant correlation (ranging from 0.02 to well beyond the 0.001 level of probability) resulted, and the estimate of tetrachoric coefficient of correlation (55 to 84%) linked native dominance with the complex environment.

Primary control of exotics came from the root and shoot competition of native subclimax or climax dominants associated with a density dependent environment containing a greater variety of life forms, physiological age classes, and vegetational strata. Since these controls are lacking in exotic dominated areas, wild land managers should focus on the ecology of the site by taking advantage of these factors or restoring them through natural regeneration. Exotic plant removal (herbicides, burning, etc.) supplements the primary control which is the same for all exotics at a site. This is the basis of the new strategy of exotic plant control on wild lands that was tested in this replicated experiment.

The focus on populations as the result and on their autecology as the manipulative means is the heart of consumptive use strategies. Such strategy solved the kudzu problem, but allowed other exotics to become problems. The factors that controlled exotics at these sites were synecological. This new focus is on communities or ecosystems as the result and on factors that govern populations and communities as the manipulative means.

L.K. Thomas, Jr.
Research Biologist
National Capital Regional Office

International Relationships with Mexico

National park units located on or near the International Border with Mexico often face unique challenges arising from cultural and economic differences between our two nations. Managers sometimes struggle to understand and deal with these cultural differences in solving mutual problems. Organ Pipe Cactus National Monument faces a particular challenge in this regard in that a major frontier lands agricultural development project has been undertaken by Mexico adjacent to the monument. More than 25,700 acres of land have been cleared and placed under irrigation over the past 20 years. This large development, and the attendant urbanization that follows, poses a serious potential threat to the natural resources of the monument.

Two studies, undertaken in 1987 under the aegis of a larger research effort known as the Sensitive Ecosystem Program, have greatly contributed to Organ Pipe Cactus National Monument's ability to understand the needs of and work with official Mexican counterparts. The first of these studies was an evaluation by private consultant Dr. Carlos Nagel of all extant bilateral agreements, laws, and treaties with Mexico that affect resource management programs at Organ Pipe Cactus. Dr. Nagel uncovered and evaluated 13 such relevant international agreements. His report has been published as Cooperative Park Studies Unit, University of Arizona (CPSU/UA) Special Report No. 8 entitled "Report on Treaties, Agreements, and Accords Affecting Resource Management at Organ Pipe Cactus National Monument."

The second study was an evaluation of land use practices adjacent to the monument. This study was undertaken by private consultant Bruce Brown and has resulted in a report that will soon be published as a CPSU/UA technical report entitled "Land Use Trends Surrounding Organ Pipe Cactus National Monument." The significance of this study was that Mr. Brown and his research team were able to establish strong information sharing relationships with several Mexican government offices at the local, state, and federal levels. Information such as groundwater consumption, electricity usage, acreage under cultivation by crop, pesticide use, etc., has been shared with the monument. The monument has in turn shared maps and resource management support, information, and training with Mexican counterparts.

Relations have never been better across the international boundary at Organ Pipe Cactus National Monument. The efforts of Carlos Nagel and Bruce Brown and their respective research teams, working closely with Superintendent Harold Smith and his staff, have led to the development of this highly desirable cooperative environment.

Dennis B. Fenn
CPSU Unit Leader/Soil Scientist
University of Arizona, Tucson

Bringing Cave Management to Light at Lava Beds National Monument

Caves are an often neglected resource that, due to the extreme slowness of the processes which renew them, can degrade irreversibly without proper management. Lava Beds National Monument contains over 100 lava tube caves, the remnants of an ancient "plumbing system" which carried hot lava down the flanks of the Medicine Lake Volcano. The caves are nonrenewable resources with unique geologic features, ice formations, cultural and historic features, and are an important habitat for two species of bats.

In 1987 the monument initiated a comprehensive program of cave management that included the development of a cave management plan, a cave inventory, and a resource and visitor monitoring program. A cave specialist was hired to write the cave management plan and to arrange for the inventory and monitoring projects to be done. Formal and informal input was solicited from cavers, researchers, cave management specialists, and monument staff.

The cave management plan attempts to balance the need of the caves for protection with the needs of the public for access, interpretation, enjoyment, and safety. Caves are assigned to management classes, each class providing for a different balance of these needs. Class 1 "Developed Caves" provide the maximum visitor access and the minimum acceptable protection of the resources. Class 2 "Undeveloped Caves" provide some visitor access and a greater degree of cave protection. Class 3 "Protected Caves"

provide minimum visitor access and maximum protection (without gating). Class 4 "Special Use Caves" each have different concerns and are managed according to cave-specific management plans. The primary techniques called on to accomplish the visitation and cave protection goals are educating visitors via signs, brochures, interpretive programs, and cave registers; limiting the availability of cave location information; establishing cave restoration programs; and altering the existing roads and trails. Gating is allowed only for Class 4 caves.

Inventory and monitoring projects will help determine the proper management style for each cave, and allow continual reevaluation of the effectiveness of management. These projects are being accomplished through contracts and cooperative agreements. A contract has been let for a study of the dynamics of ice growth in Crystal Ice Cave, and a cooperative agreement has been awarded to the University of Washington for a visitor survey. The remainder of the work will be done through a cooperative agreement with The Cave Research Foundation (CRF), a non-profit volunteer research organization. CRF projects will include cave mapping, a cave resource inventory, a bat survey, an invertebrate survey, the design of a monitoring program, and the development of a computer data management system. For information, contact Charisse Sydoriak, Chief, Resource Management, Lava Beds National Monument.

Janet Sowers
Cave Management Specialist
Formerly with Lava Beds National Monument



Wetland Regulatory Compliance: A Guidance Manual for the National Park Service, Mid-Atlantic Region

Wetlands are an imperiled natural resource in the United States, with less than one-half of the original wetland acreage in the lower 48 states remaining. Since its creation, the National Park Service has been involved in preserving these valuable aquatic resources through its mandate outlined in the National Park Service Organic Act (16 USC 1). However, this mandate often requires park managers to make choices regarding construction of access, interpretation, and resource protection facilities which have the potential to impact wetlands. Visitor protection and prevention of damage to or loss of facilities also enter the management equation when facilities have been placed in floodplains and their associated wetlands.

At the request of the Mid-Atlantic Region, a manual has been prepared to assist parks in navigating the sea of regulatory procedures designed to protect wetlands from further degradation or outright loss as a result of NPS actions. The information presented in the manual may also be useful in situations where activities in wetlands outside park borders could impact NPS resources.

Introductory material in the manual includes discussions of wetland types, wetland functions and values, and sources of wetland impacts. Laws, regulations, and policies related to wetlands are then presented, with special emphasis on provisions of Section 404 of the Clean Water Act, Executive Order 11990 ("Protection of Wetlands"), and the NPS *Floodplain Management and Wetlands Protection Guidelines*. Flow diagrams are included as a means of condensing the wetland protection requirements, including provisions for emergency situations, into a set of step-by-step compliance procedures. In the final chapter, methods are suggested for conducting the wetland inventories required under the NPS guidelines, and procedures for onsite identification of wetlands and determination of their borders are discussed.

Joel Wagner
Hydrologist
Water Resources Division

Western Region Develops Program of Tree Hazard Detection, Mitigation, and Training

Since 1963 there have been 13 fatalities and 24 serious injuries associated with tree failures in Western Region parks. During this same period, tree failures have resulted in an estimated \$9 million in damage to NPS facilities and another \$2.5 million in damage to visitor property, primarily automobiles. In 1979, the U.S. Forest Service conducted an economic analysis of the Yosemite National Park tree hazard program and concluded that the Service would save \$50 million for every dollar spent in tree hazard mitigation. Since 1985 there have been in excess of \$50 million in tort claims filed in association with tree failures within Western Region parks.

A 10-person Western Region Tree Hazard Task Force was formed as a result of a moral and ethical obligation to manage tree hazards. This task force has been working for two years now on the development of a Tree Hazard Management Handbook intended to bring integrity and professionalism to our tree hazard management efforts and, hopefully, reduce the potential liabilities associated with such hazards. The handbook outlines a comprehensive management program of tree hazard detection, mitigation, and training.

Tree hazards will be systematically eliminated in 27 Western Region parks to a predetermined, acceptable level of management risk in accordance with a standardized tree hazard rating system adopted for the region. The management program defined in the handbook addresses the regional standardization of mitigation techniques; the development of a training curricula for tree surveyors and mitigation personnel; and required documentation of tree hazard surveys and work accomplishments via maintenance management system. Work will be done via "in-house" labor, small contracts, and a Western Tree Hazard Mitigation Team. Program coordination and budgeting will be the responsibility of a Tree Hazard Coordinator in the Western Regional Office. Initial elimination of tree hazards and general reduction of liabilities will occur principally over the first 10 years of the program and thereafter conducted at a maintenance level.

Thomas M. Gavin
Regional Forester
Western Regional Office

Historic Meadow Restored At Franklin Delano Roosevelt Home

One of the things that President Franklin Delano Roosevelt enjoyed most about his home in Hyde Park, New York, was the view down the Hudson River and across to Ulster County. This vista often featured prominently in his writings and public addresses, and became well-known to the public during his lifetime.

Over the years, a creeping invasion by woody plants, notably the pugnacious Tree-of-Heaven (*Ailanthus altissima*) resulted in the almost total loss of the President's beloved vista. In the fall of 1988, a contract was let to clear, grade, and hydroseed 20 acres, with the goal of restoring the hay meadow that had been lost to woody plants and of opening up the vista. (Maintenance of the vista was actually stipulated by FDR in the deed of property transfer.)

Metzger Construction Inc., of Hopewell Junction, New York, moved in and quickly reduced 20 acres of trees to a two-story pile of chips using a tree shear and a MASSIVE wood chipper. Special care was taken to prevent two archeological sites within the project boundary from being impacted by the heavy equipment. Stumps were removed and buried, and the area was rough-graded. In April, a mix of alfalfa, timothy, oats, birdsfoot trefoil, lime, fertilizer, water, and a binder was spread over the site using a hydro-seeder. The area then was mulched.

After the hay is established, the area will be included in the Roosevelt-Vanderbilt's agricultural permit program. Within a year, the meadow and resultant vista clearance will greatly enhance the historical accuracy and integrity of this important cultural landscape.

Duane Pearson
Superintendent
Roosevelt-Vanderbilt National Historic Site

Water Rights Protected at Great Sand Dunes

State appropriative and federal reserved water rights for instream and present and future consumptive needs were recognized for Great Sand Dunes National Monument in Colorado as a result of a negotiated settlement. While the recognition of these rights is not considered as precedent setting because they resulted from a negotiated settlement, the settlement is, none-the-less, significant to NPS management. Of special importance is the fact that the result demonstrates the potential for successful settlement of water rights issues outside of the contentious and expensive litigation arena.

The Great Sand Dunes National Monument, in south-central Colorado, was created in 1932 "for the preservation of the great sand dunes and additional features of scenic, scientific, and educational interest." The portion of Colorado in which the monument is located contains the third of Colorado's seven water divisions. These divisions represent large watersheds in which the state administers the right to use water.

In 1979, the United States was made party to a basinwide law suit, called an adjudication of water rights, in which all claims to the right to use water would be either legitimized or refuted by the court. Consequent to being jointed in the lawsuit, the Department of Justice, representing the National Park Service and other federal land management entities, filed claims for appropriative and federal reserved water rights. During 1987 the Water Resources Division became actively involved in the development of the technical testimony which would be required in the expected litigation.

Court decisions have held that federal reserved water rights exist only in the amounts necessary to prevent defeat of the reservation's primary purposes. The initial problem was to establish the monument's water needs, including instream flows, as related to monument purposes. To make the link between monument purposes and a reserved right, legislation establishing the monument, the scientific literature, and historical reports and newspaper editorials were researched. The need for water to support reservation purposes at first appeared very limited in light of the purposes for which the monument was created.

The key was found in the scientific and engineering literature. A unique, or at least unusual, phenomenon occurred on the monument's two principal drainages. Specifically, Medano and Sand Creeks were known to have demonstrated "pulsating" for "surge" flow. That is, these streams displayed a flow regime in which wave fronts moving downstream were created by the periodic formation and collapse of bedforms which impounded and then released water. The significance of the phenomenon to monument purposes was further supported by identifying educators who had both discussed the phenomenon with their students and taken classes to view the surge flow.

Additional research lead to the discovery that Medano Creek transported substantial quantities of sand from the downwind to the upwind extremities of the stable dune mass. This information evolved into the premise that this sediment transport recycled the aeolian sand thereby arresting the motion of the dune mass and producing its unusual height.

Little streamflow data for the Great Sand Dunes area was available. It was thus necessary to extrapolate the limited data using watershed characteristics to predict flow in the several ungaged watersheds within the monument.

Using the foregoing, the Water Resources Division developed: (1) two bases for entitlement (the scientifically important pulsating flow regime and the role of Medano Creek in stabilizing and deepening the dune mass, contributing to its uniquely important character); (2) a defensible need for instream flow in streams tributary to Medano and Sand Creeks (they contribute to achieving the purposes served by these streams by contributing to their flow); (3) the quantification of the NPS reserved water right (the mean annual discharge, prorated on a monthly basis); and (4) a computation of future consumptive water need.

Department Of Justice attorneys, armed with the above and local concerns over new Spanish land grant based applications for large amounts of groundwater, pressed for settlement outside of litigation. The attorneys were successful in producing a consent decree which recognizes the mean monthly discharge of Medano and Sand Creeks along with their 14 named and unnamed tributaries and 8 acre-feet for future consumptive uses by the park.

Owen R. Williams
Chief, Water Rights Branch
Water Resources Division

Friendship Hill Pilot-Scale Wetland Research Status Report

As a result of the joint National Park Service and Bureau of Mines (BOM) effort to develop a constructed wetland to treat acid mine drainage (AMD) that flows across the Friendship Hill National Historic Site, a novel constructed wetland was built during the summer and fall of 1988. This wetland design incorporates biologically mediated mechanisms believed to be important for a constructed wetland system to treat AMD, especially of the composition (pH 2.6 and iron concentration of 300 mg/L) found at Friendship Hill. The result of this effort is the construction and operation of a flexible test bed that should allow the assessment of the feasibility of a full-scale constructed wetland design for Friendship Hill and advance the BOM biotechnology program.

During the autumn of 1986, a pilot-scale wetland was constructed with cattails and sphagnum moss and exposed to AMD. During the winter and early spring of 1987, concentrations of total iron in the outflow averaged 79 mg/L less than the inflow. During this period, the sphagnum moss was green and 80-90% of the cattails were sprouting. Between mid-April and early August iron concentrations were decreased only by 15 mg/L and there were visible changes in the vitality of the moss and cattails. By August 1987, the sphagnum moss had developed a rust color and was 95% dead. During this same period, over 80% of the cattails died.

These initial results indicated that long-term water quality improvement could not be achieved at Friendship Hill by simply creating a shallow water system and planting it with sphagnum moss and cattails. It appeared that the Ice Pond Run water is too acidic and metal-laden for this type of wetland, which was the state-of-the-art at that time.

During the summer of 1988, the pilot-scale wetland design was modified to test the effectiveness of a cattail/mushroom compost system with varying methods of alkalinity generation. In light of the severity of Ice Pond Run AMD and the general lack of data on long-term wetland performance, our pragmatic goals are to establish a viable vegetative wetland community, lower the iron concentrations to about 50 to 75 mg/L, and raise the pH to about 4.

The original cattail plots were reconfigured into two sections (or cells), separated from the sphagnum moss plots and from each other by earthen berms. Three lanes of water flow (see illustration on the following page) were created in each cell using sheets of fiberglass paneling. Each lane was filled with about

18 inches of mushroom compost and planted with cattails that were collected locally. Lane A, the alkalinity control lane, had 47 tons of noncalcareous river gravel spread in a 6- to 8-inch layer at its base. Lanes B and C received equal amounts of limestone gravel. Lane C will receive periodic surface additions of alkaline materials.

Water flows between cells (but within lanes) by way of PVC plumbing installed in the berm separating the cells. The second set of cells also contains an "underflow" system (subsurface infusion pipes) which will allow inflow of water into the gravel at the wetland base.

This design will allow comparisons of metal, acidity, and sulfate removal in the cattail/mushroom compost system that is subjected to additions of alkalinity beneath the substrate, at the surface, and a control (no additional alkalinity). The experimental underflow system should cause movement of water through anaerobic organic materials and reducing conditions.

Water samples will be collected biweekly from the common inflow to the first cells, between the first and second cell in each lane, and at the outflow of each cell.

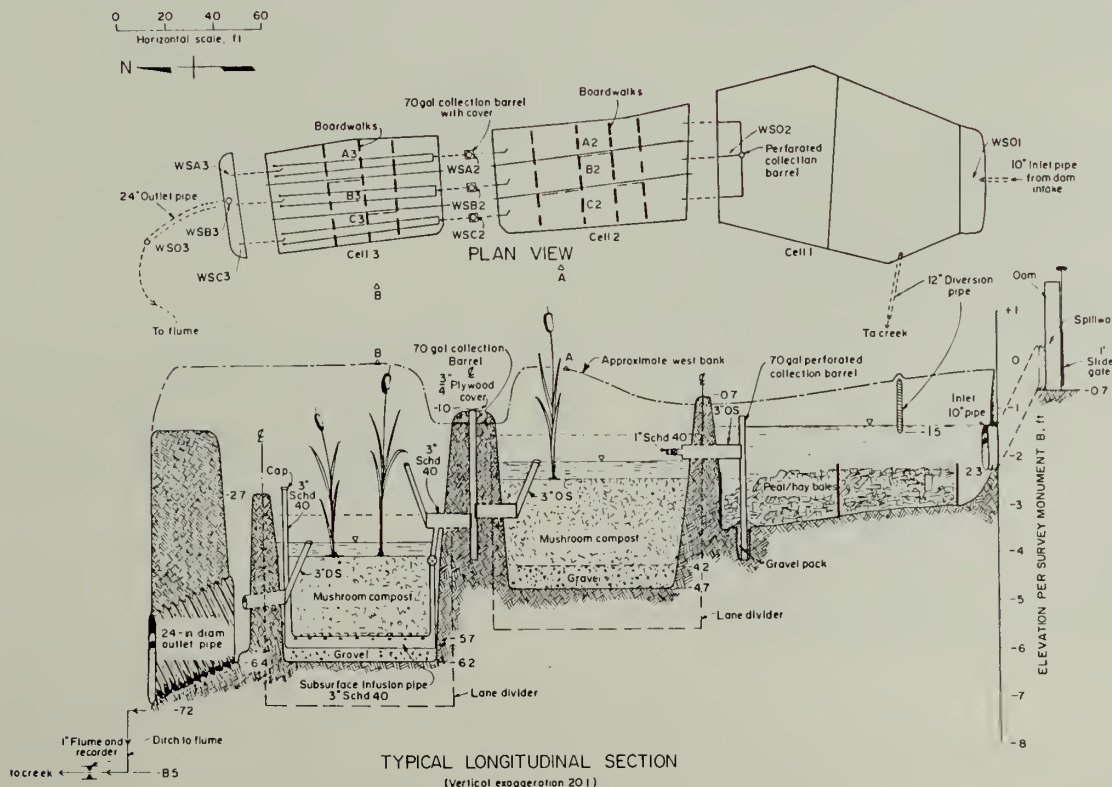
The pilot-scale wetland was put into operation in late October 1988. The wintertime period is being used to troubleshoot the physical operation of the relatively

complex wetland design, and to collect data describing the establishment of a wetland ecosystem. A variety of sampling devices have been deployed in the wetland. Volume and water sampling is performed biweekly.

To date, the most interesting observations have been made in the cells where the subsurface infusion pipes were operated for a two-week period. The chemistry of the water coming from these cells was markedly different from the water in cells that experienced only surface flow of AMD. The cells having subsurface flow raised the pH of the water from about 3 to about 6 and also lowered metal concentrations.

These effects may only be due to sorption, cation exchange, and the dissolution of gypsum in the organic substrate. Although sulfate-reducing bacteria are present and active in the substrate, their contribution to wetland performance will not be clear until the initial influence of the AMD-mushroom compost chemistry has subsided. The spring of 1989 will represent the first growing season for the pilot-scale wetland and will be the beginning of an intense monitoring and sampling program by the Bureau of Mines.

John Karish
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Water Resources Management Planning in the National Park Service

In carrying out its management responsibilities in units of the national park system, numerous water resource issues, concerns, and needs have become apparent to the National Park Service. More specifically, a recent systemwide, natural resource assessment carried out by the Park Service identified significant water resource issues such as the degradation of park water quality due to external activities, the alteration of natural flow regimes and groundwater levels (caused by both in-park and external development), and the lack of secure water rights. The assessment also identified other water resource issues such as disruption of natural coastal dynamics, disruption of park resources due to mineral extraction and geothermal activities, impacts of urbanization, visitor use impacts on backcountry park resources, and lack of basic data necessary to understanding park ecosystems and threats to them.

An essential step in addressing these water resource issues is park planning. Planning provides a mechanism to gather and analyze data, assess existing conditions and future trends, identify issues that need to be addressed, evaluate, as appropriate, alternative actions, and recommend actions. In addition, park planning is a fundamental tool in preparing budgets and allocating funds and staff to parks. Actions recommended by the planning process may include research/documentation, mitigation/treatment, monitoring, protection/enforcement, and program administration/training.

In some parks, where water resource issues are sufficiently important, complex, or controversial, a water resources management plan (WRMP) may be prepared as a separate action plan of the natural resources management plan. The Water Resources Division issued "Instructions for the Preparation of Water Resources Management Plans" in 1978 and has recently revised these instructions to reflect experience gained in preparing a number of WRMPs and to ensure consistency with recent changes in the Park Service's approach to natural resource management planning. The WRMP specifically supports the NPS decision-making process related to the protection, conservation, use, and management of park water resources. Responsibility for preparation of the WRMP lies with the park. Specific direction, guidance, and technical support may be provided by the NPS regional offices and the Water Resources Division.

The Park Service has prepared WRMPs for Cape Cod National Seashore, Glen Canyon National Recreation Area, Grand Canyon National Park, Sequoia and Kings Canyon National Parks, Redwood National Park, Santa Monica Mountains National Recreation Area, Lake Mead National Recreation Area, and Mount Rainier National Park. Currently, the Park Service is preparing WRMPs for Delaware Water Gap National Recreation Area, Chickasaw National Recreation Area, Grand Teton National Park, Capitol Reef National Park, Organ Pipe Cactus National Monument, Montezuma Castle and Tuzigoot National Monuments, Golden Gate National Recreation Area, and Yosemite National Park. It is expected that WRMPs will be prepared in the very near future for many additional units of the national park system.

Dan B. Kimball
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Water Resources Division

Assessing Impacts on Hydrology of Cumberland Island

The navigation channel through the St. Marys Entrance to King's Bay, Georgia, has been deepened and widened several times since the 1950s, initially for the Army's Military Ocean Terminal and more recently for the Navy's trident submarine program. Present plans call for the channel to be deepened 9 feet to an operations depth of 46 feet and a construction depth of 51 feet.

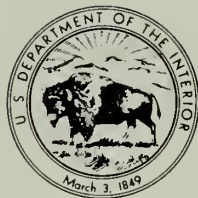
The deepening of the navigation channel could impact the freshwater resources of Cumberland Island National Seashore, which borders the channel to the north and east. Ultimately such deepening could impact the island's ecological balance by adversely affecting the plant and animal communities that are dependent on the freshwater resources. Potentially, channel deepening could breach freshwater and groundwater zones and alter the freshwater resource of the entire island. Specifically, it could increase salinity of island lakes, streams, and marshes; lower ground-water levels and reducing the size and extent of freshwater lenses; and promote saltwater intrusion into deeper aquifers through breaches in overlying confining units.

An investigation of southern Cumberland Island has been initiated to define the freshwater flow system, the location of the freshwater-saltwater interface, and the general hydrogeologic setting. A network of nested wells will be constructed to provide water-level and water-quality data to evaluate changes that may occur as a result of channel deepening. Borehole geophysical logs will provide information about the hydrogeologic characteristics of the subsurface and will be used to define the hydrogeologic framework. Surface geophysical surveys will provide additional hydrogeologic and water-chemistry information and will be used to delineate the freshwater-saltwater interface.

Weather stations will be installed to define the interplay between the island and the atmosphere. A water budget will be calculated to evaluate groundwater/surfacewater relations on the island. Several stage recorders will be installed on island lakes to determine the tidal influence, and to define the relation between

island lakes and shallow aquifers. Information compiled from previous studies of the geology, hydrology, and water quality of Cumberland Island and surrounding areas will be incorporated into this study as control data to evaluate changes in the flow system resulting from channel deepening.

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As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people. The department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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